CBARR Investigates Sea-Dumped Munitions in the Pacific Using Human-Operated and Remote-Operated Vehicles (HOV-ROV)

John L Schwarz, Michael E Knudsen, Lou S Alvano, Michael C Glorioso

US Army Edgewood Chemical Biological Center, APG 21010, MD

Project Timeline: Discovering the Unknown

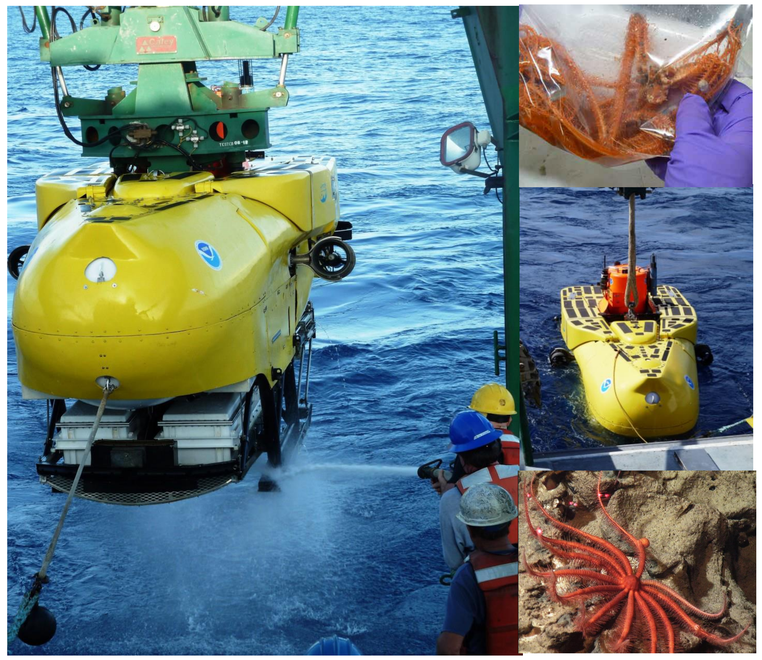
Sea-dumping munitions was not an uncommon practice during the 20th century, and in 1972 the United States formally banned sea disposal when Congress passed the Marine Protection, Research and Sanctuaries Act. Understanding the resulting environmental impact has led to critical research being conducted by the U.S. Army and Margo Edwards, principal investigator for the University of Hawaii at Manoa: the Hawaii Undersea Military Munitions Assessment (HUMMA) project. Since 2007, Edwards has led the HUMMA project, a five-phase $7.5 million research effort for the Office of the Deputy Assistant Secretary of the Army for Environment Safety and Occupational Health. When the project started in 2007, no one really knew where to look or what they were going to find. It was a real unknown with a project framed with a number of questions:

- Are we going to be able to detect the munitions with sonar technology?
- Are we going to be able to visit the munitions if we locate them?
- Are we going to be able to collect the samples that we need to?

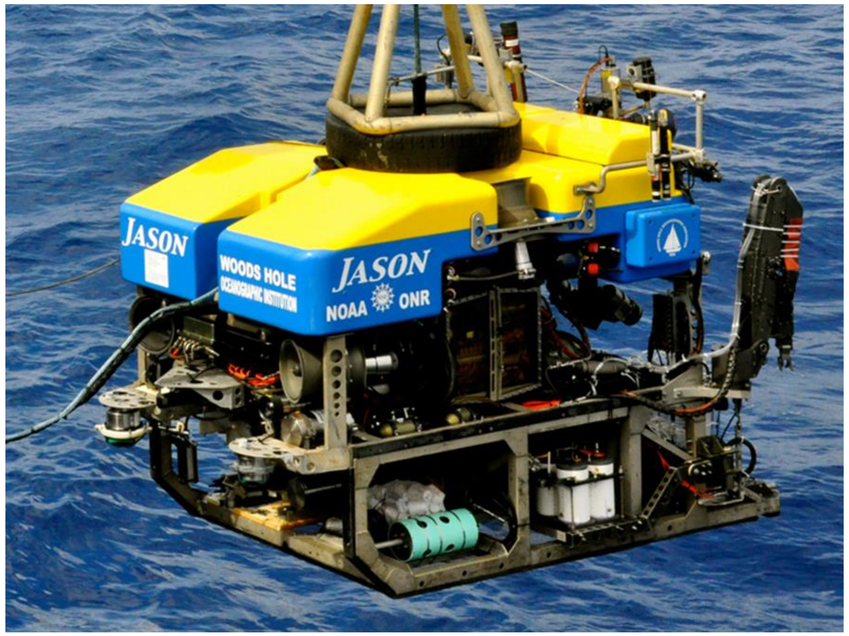
Researchers were pretty sure the answer to all of those questions was going to be 'yes' but in those water depths and with the technology at the time, it had never had never been attempted before. Eight years later, researchers are asking some very sophisticated yet fundamental questions about how these munitions are deteriorating.

Collecting Ocean Samples with the PISCES HOV

ECBC has supported the research effort as chemical experts since 2009 when a team of CBARR scientists first conducted sample analysis onboard a research vessel off the coast of Oahu. More than 50 hours of video data and 3,500 images of munitions were collected as the university and prime contractor Environet investigated parts of a 500 square-kilometer region of ocean floor using the three-person PISCES submersibles. In 2012, ECBC supported the second phase of the HUMMA project, which included using the same submersibles to descend to the bottom of the ocean and collect samples within 10 feet of the munitions. Nearly 300 samples were collected, including 165 sediment samples, five water samples and 36 samples of shrimp tissue. This was also the first time the Hawaiian Brisingid starfish were discovered among the deteriorating chemical munitions.



LEFT: Crew members wash off the PISCES sub-mersible before docking it on the boat. Photo credit: Environnet. TOP: (R) A Brisingid sea star was collected and shipped to Smithsonian scientists to study. (R) The underwater vehicle pre-pares for its 30-minute dive nearly 550 meters below the water's surface to collect samples. BOTTOM: A Brisingid sea star hovers near the ocean floor, where scientists have discovered its natural habitat near old chemical warfare munitions.



Samples were collected using the JASON Remote Operated Vehicle (ROV) from the Woods Hole Oceanographic Institution; shown here preparing for its descent to where chemical munitions are found 500-600 meters underwater off the coast of Hawaii. (Photo courtesy of University of Hawaii)

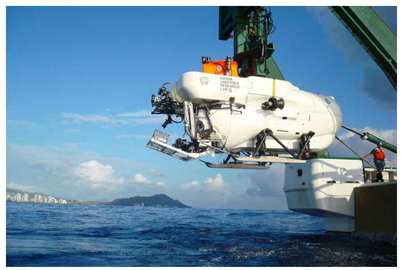
Lessons Learned Along the Way

The lessons learned in 2012 enabled ECBC to return in 2014 with proven analytical methods for monitoring as well as overall laboratory design onboard the ship. Now, with the final phase of the HUMMA project complete, the U.S. Army and the University of Hawaii evaluated performance differences between human-occupied (HOV) submersibles and the ROVs used during the last mission. Trace amounts (parts per billion) of mustard agent, along with several degradation products, were detected in the sediment where chemical munitions were known to be found 500-600 meters underwater.

JASON ROV Collects Samples from Ocean Floor

In October 2014, CBARR supported a one-week UH research effort where ROVs collected 442 sediment scoops, 35 water samples, 84 shrimp samples, 11 starfish and 2 anemones, and 28 box cores, which is similar to a piston that is pushed into the sediment to maintain consistent layering when it recovers the sample. Throughout the course of the multi-year research effort, other data has been collected, including more than 100,000 still images plus high resolution video data that was captured from multiple cameras. CBARR analyzed double the amount of samples as in 2012 and in half the time. Using the JASON ROV that could submerge for 36-48 hours at a time, researchers were able to go closer to the munition and collected 8-16 samples at each location. This significantly improved productivity and eliminated the safety risk of having people onboard an underwater vehicle for extended periods of time.

Mustard agent freezes at a temperature of 58^{o} F, so there is little to no environmental risk to the ocean at these depths, where the average temperature is 45 degrees Fahrenheit. Samples from the research were sent back to the EML, where further studies were investigated determining what kind of



TOP: Since 2009, ECBC has supported the HUMMA project. (Photo courtesy of UH)

LEFT: A small amount of neat agent, about the size of a sugar package, was sampled and analyzed by the ECBC team onboard the research vessel at sea. (Photo courtesy of University of Hawaii)

It's no secret that chemical munitions from World Wars I and II are still around today. Though their use is prohibited by the Organisation for the Prohibition of Chemical Weapons (OPCW), they can be still found in stockpiles or recovered from land, and are waiting to be destroyed. They are also found at the bottom of the ocean, where they have corroded for nearly a century and can disintegrate upon touch.

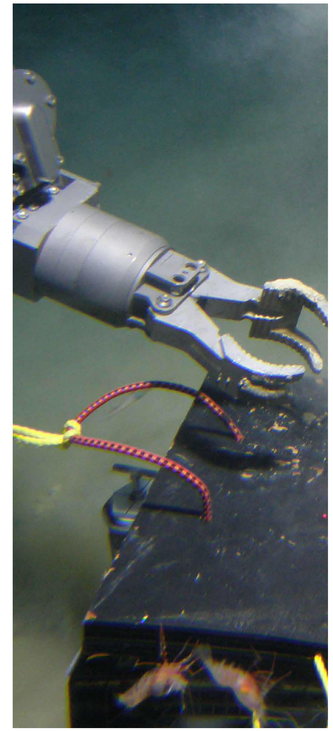
JASON ROV Collects Samples from Ocean Floor (cont'd)

bacteria lives in the sediment found at that depth in order to determine other things like oxygen content, metals analysis and toxic industrial compound levels. But the mystery remains: at what point did the munitions start leaking mustard?

The data point to an answer that is consistent across the biology and sediment samples as well as the level of collapse seen in the munitions. Since no one was present at the time of the sea dumping and, although it cannot be proven definitively, HUMMA researchers are building a compendium of evidence that suggests that the leakage from these munitions mostly occurred 70 years ago when they were first dumped into the ocean. Sea water is a natural catalyst for corrosion and has accelerated the rate of disintegration for the munitions. It's a relatively slow process to investigate the current condition of the munitions when the atmospheric pressure at that depth is 65 times the atmospheric pressure at sea level; all the more reason to use ROVs when collecting samples.

After years of research, the HUMMA team have sampled around 50 munitions site locations—a small, yet multi-faceted data set that indicates neither the munitions nor their chemical contents have impacted sea life significantly. For example, the team discovered that one species of starfish often selects munitions as a natural habitat. Edwards and her team worked with scientists at the Smithsonian Institution to study the lesions on the arms of starfish that were collected living on munitions. These lesions were hypothesized to be a result of contact with mustard agent. After extensive investigation, the Smithsonian Institution not only realized that this was a new species of starfish, but concluded that the lesions were the result of a parasitic barnacle invading the arms of the starfish. The parasitic barnacle itself may also be an undiscovered species.

"Every aspect of this project has taken us in new directions where we discover amazing things that we just didn't know," Edwards said.



ABOVE: The robotic arm of a remotely operated vehicle collects sediment and water samples where chemical munitions are found 500-600 meters underwater off the coast of Hawaii. (Photo courtesy of University of Hawaii)